The Making of the Chemist

The Social History of Chemistry in Europe, 1789–1914

Modern chemistry, so alarming, so necessary, so ubiquitous, became a mature science in nineteenth-century Europe. As it developed, often from a lowly position in medicine or in industry, so chemists established themselves as professional men; but differently in different countries. In 1820 chemistry was an autonomous science of great prestige – Humphry Davy became President of the Royal Society, for example – but chemists had no corporate identity. It was not until 1840 that national chemical societies were first formed; and many countries lagged fifty years behind the leaders. Chemists are the largest of scientific groups; and in this book we observe the social history of chemistry in fifteen different countries, ranging from the British Isles to Lithuania and to Greece. There are regularities and similarities; and by describing how national chemical professions emerged under particular economic and social circumstances, the book contributes significantly to the European history of science.

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The Social History of Chemistry in Europe, 1789–1914

Edited by

DAVID KNIGHT & HELGE KRAGH

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The European Science Foundation (ESF) acts as a catalyst for the development of science by bringing together leading scientists and funding agencies to debate, plan and implement pan-European scientific and science policy initiatives.
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Preface

Chemistry is very old. Dyes, drinks, drugs and metals have been prepared and purified all over the world for thousands of years; and there have long been experts, doing these things for a living. But we might disagree about when chemistry became a science: that is, a body of factual, empirical knowledge combined with theoretical understanding. Theories of yesterday, or the day before yesterday, may seem quaint or simply false, because science is a dynamic and progressive business: but without theory a mass of facts is not a science. Historians differ: perhaps alchemists in China, or in the Hellenistic or Islamic world, made chemistry a science; or contrariwise, Paracelsus, active around 1500, founded it; or else Robert Boyle, son of the Earl of Cork, fathered chemistry in the 1660s. Again, the idea of Joachim Becher and Georg-Ernst Stahl that everything which would burn contained 'phlogiston' brought a new coherence to chemical thinking in the eighteenth century: maybe they began the science.

We have chosen to begin our stories with Antoine Lavoisier,[1] whose classic book was published in 1789. He saw himself as carrying out in chemistry a revolution like that which was beginning in his native France at the same time: sweeping away old practices and conventions, and bringing in the rule of right reason. In the light of the evidence in this book, it will not be very plausible to echo the words of Adolph Wurtz, 'Chemistry is a French science: its founder was Lavoisier of immortal fame;' but we cannot doubt that the science took a new direction at this point. Not only were its experiments spectacular, but its theory and its language[2] – moving rapidly from poetry towards algebra – indicated that it was the fundamental science, casting light on the inner structure of matter, and the forces responsible for its properties. Audiences, fashionable and

[1] A. Donovan, *Antoine Lavoisier: Science, Administration and Revolution*, new ed. (Cambridge: Cambridge University Press, 1996); B. Bensaude-Vincent, Lavoisier: *Mémoires d'une Révolution* (Paris: Flammarion, 1993).

[2] L. B. Guyton de Morveau *et al.*, *Méthode de nomenclature chimique* [1787], intr. A. M. Nunes dos Santos, Lisbon: Petrogal 1991; D. M. Knight, 'Chemistry and metaphors', *Chemistry & Industry*, 20 Dec 93, 996–9.

artisan, men and women, flocked to hear chemical lectures,[3] accompanied by demonstrations. Lavoisier's account of breathing as absorption of oxygen showed how chemistry underlay the processes of life; while Joseph Priestley, Alessandro Volta and others linked it to the mysteries of electricity. A period of very rapid development began.

In 1789 there were few posts available for chemists. Those doing pharmacy might be so described, and indeed in Britain the pharmacy is still colloquially 'the chemist's shop.' Medical courses included chemistry; and some apothecaries, surgeons and physicians performed chemical research or (not always the same people) taught the science. Metallurgy, and the bleaching and dyeing of cloth, involved formal or empirical knowledge of chemistry. Eminent chemists might equally: hold important and lucrative posts in government administration, like Lavoisier; be landed gentlemen, like Henry Cavendish; or clergymen, like Priestley or Bishop Richard Watson. There was no single route to becoming a chemist, and little sense of a 'chemical community': the science came to interest members of all classes in society, with its intellectual excitement and its promise of usefulness, but its practitioners had little in common.

Following the French Revolution, war broke out all over Europe; and it soon became a world war, with fighting in India, Syria and Egypt, the new USA, and on the oceans. With brief intermissions in 1802 (the Peace of Amiens) and 1814, fierce fighting continued until the battle of Waterloo in 1815. Chemists had some importance in this warfare: they were involved in the gunpowder industry; and in France the programme of melting down church bells to make gunmetal (a bronze of somewhat different composition) was in their hands. However, although Britain's Royal Navy experimented with rockets, this was a war of generals and admirals, where applied science, in the form of Britain's industrial revolution, was important only in the background as economic power.

1815 was memorable not only for bringing peace, but also for Humphry Davy's safety-lamp for coal miners: one of the first devices to be developed by a chemist in the laboratory, which solved a major problem in industry, and indeed in national life not only in Britain but in mining districts elsewhere in Europe. It brought immense prestige to Davy and to his science. Then, as medical education was made more formal across Europe, so chemistry gained a more secure place in universities, which, particularly in Germany, were becoming places where research was done in association with teaching. By the middle of the century, the chemist was likely to have a degree, probably in pharmacy or medicine but perhaps in arts, and to have gone on to supervised research. Laboratory instruc-

[3] J. Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760–1820* (Cambridge: Cambridge University Press, 1992).

tion, rather than demonstration by the professor, was also becoming general even for undergraduate students and first degrees in chemistry were possible; Justus von Liebig's laboratory at Giessen where he trained numerous chemists for PhDs became particularly famous – at that time, the degree might take less than a year. A recommendation from a 'father in science' like Liebig was very valuable for anybody seeking an academic post, as older systems of patronage declined.

In the 'hungry forties' people all over Europe looked to chemists to solve this great problem of national life and prove Thomas Malthus wrong; and Liebig became particularly famous for his work on fertilisers. We may feel alarm at synthetic fertilisers and explosives; but in the nineteenth century they were unequivocally welcomed as progress, bringing food and better communications in the form of railways and roads. By the 1850s, as the great age of international exhibitions began, there was increasing faith in science and the technology and prosperity which seemed to flow from it; in chemistry, this became evident to every eye with the new synthetic dyes, mauve, magenta and their successors, bringing a new depth and brilliance to the colours of clothes, curtains and carpets.

Chemistry,[4] as the science dealing with smells, colours and tastes (and where skilled fingers were needed), had a wide appeal; but it was difficult to learn. There was so much to remember; and theory was hard to apply. Lavoisier had explained combustion as combination with one of the gases which composed the air, 'oxygen'; and saw 'simple substances' or elements, which could not be decomposed, as the basis of chemical science. John Dalton, in the first decade of the nineteenth century, ascribed a different kind of atom to each element; and drew diagrams of the structures of compound substances. However, it was not clear whether, for example, water was composed of one atom of hydrogen with one of oxygen (the simplest formula, favoured by Dalton), or two atoms of hydrogen and one of oxygen (favoured by Amadeo Avogadro, André-Marie Ampère and others, because two volumes of hydrogen combine with one of oxygen). J. J. Berzelius proposed the notation we now all use, where H stands for an atom of hydrogen, O for an atom of oxygen, etc.; but uncertainties about the formula for water and other simple molecules meant that different chemists expressed chemical recipes differently. There were no universally-accepted chemical equations which balanced.

In 1860 came the first major international conference of chemists, at Karlsruhe;

[4] Recent general histories of the science, emphasising the nineteenth century, include B. Bensaude-Vincent and I. Stingers, *Histoire de la Chimie* (Paris: Editions la Decouverte, 1993, English translation, Cambridge, MA: Harvard University Press, 1997); W. H. Brock, *The Fontana History of Chemistry* (London: Fontana, 1992); J. H. Brooke, D. M. Knight and S. Mason, in P. Corsi & C. Pogliano (eds.), *Storia della Scienze*, vol. 4 (Turin: Einaudi, 1994), pp 48–97, 98–135, 226–63; J. Hudson, *The History of Chemistry* (London: Macmillan, 1992); D. M. Knight, *Ideas in Chemistry: a History of the Science*, 2nd ed (London: Athlone, 1995); J. H. Brooke, *Talking about Matter* (Aldershot: Variorum, 1996).

it was chaotic, but after it chemists in the wake of Stanislao Cannizzaro came to agree on the H_2O formula for water. Notation at last became uniform; and a number of chemists, most notably the Russian Dmitri Mendeleev, came up with schemes of classifying the chemical elements (of which there were now some eighty known) using the now agreed relative atomic weights. From the 1870s Mendeleev's Periodic Table came to adorn every chemical lecture room; it compressed a great deal of knowledge into a small compass, meaning that the student no longer had to be burdened with a great load of unrelated brute facts. At the same time, the spectroscope opened up new possibilities of chemical analysis without bubbling hydrogen sulphide into test-tubes, inaugurating even solar and stellar chemistry; and brought chemistry and the formidable structure of classical physics together. With thermodynamics came the beginnings of physical chemistry.

Here chemists began to play with numbers; and following on from Auguste Laurent,[5] chemists began to follow the method of hypothesis and deduction characteristic of more mathematical sciences and of crystallography. Laurent, like Dalton, believed that it was impossible to arrive at structures by generalizing from experimental data; rather, the consequences of hypothetical structures should be worked out, and the predictions tested in the laboratory. Auguste Kekulé with the benzene ring, and J. H. van't Hoff with three-dimensional molecular forms, took organic chemistry down this route. Ball-and-rod kits for making molecular models, originating with August Hofmann, were available by 1867. Chemists had long sought to isolate active components from natural products; this still remained important, but by the later nineteenth century substances like indigo were being synthesised in the laboratory (by now an imposing feature of university campuses), and then in the factory. Colonial products were thus refined by chemists, and then perhaps superseded.

Chemistry had become a mature science; not only with something like an agreed syllabus which made it the most popular of the sciences in schools and colleges, but also with its own institutions. Unspecialised academies and scientific societies, and medical 'colleges', had given space to chemistry from the seventeenth century; and it was prominent in the peripatetic Associations for the Advancement of Science which took as their model the German system devised by Lorenz Oken. Surprisingly, the first national society devoted to chemistry was founded in Britain as late as 1841. Other countries soon followed. From the beginning, there were tensions: were such societies 'professional', white-collar trades unions, setting qualifications and determining fees, lobbying for legislation; or were they 'learned', promoting and publishing research – chiefly in

[5] M. Blondel-Mégrelis, *Dire les Choses: Auguste Laurent et la Méthode Chimique* (Paris: Vrin, 1996).

academe, because industrial research produces trade secrets and brings its practitioners patents and promotions rather than publications. Sometimes, as in Britain, these two objectives proved impossible to reconcile in a single chemical society in the nineteenth century.

Lavoisier and his associates were responsible for a journal, *Annales de chimie*,[6] devoted to the new chemistry; and in the course of the nineteenth century many publications sprang up. Some took a party line in the various disputes of the day; many were associated, formally or informally, with an institution; and some were popular and accessible, while others were august and even forbidding to those not engaged in the forefront of chemical research.[7] Editors became powerful figures, determining what could and could not be published; they came to draw, formally or informally, upon the expertise of an editorial board or a team of associates as referees in a world of increasing specialism. Many journals included translated papers, because although German was becoming the language of the science not everybody read it with any ease; and because so much was published, reviews and abstracts were essential by the later part of the century. Berzelius had tried to read and report on everything in the 1820s; Liebig and H. Kopp jointly took on this task after him, but fifty years later this had become an impossible feat.

Courses in universities and technical schools, societies and journals brought into being what there had not been in 1800; a community of chemists. And this extended across Europe. The beginnings of chemistry are spread throughout the world but it came to maturity in Europe; even the USA, in our time the centre of gravity of chemistry, was peripheral in the nineteenth century. However, in 1870 came the next major European war, this time between Prussia and France: in this the more educated and scientific nation (to the surprise of outsiders) overwhelmed its opponent. Like the launching of 'Sputnik' in 1957, this gave a tremendous boost to education, particularly technical and scientific education, everywhere. The new German university in Strasburg, in the conquered territory of Alsace, was a showpiece; and in Nancy came the French riposte. Even in Britain with its traditions of self-help and *laissez-faire*, compulsory state education was introduced in 1870, and significant government support for the now-burgeoning universities followed.

This war, and those which had led up to it, meant a major revision of the map of Europe. The unification of Italy was completed; Denmark and France lost provinces to what was now the German Empire with its capital in Berlin, though not yet a single unitary state like France. Germany in 1789, and still to a great

6 M. P. Crosland, *In the Shadow of Lavoisier: the Annales de chimie and the Establishment of a New Science* (Oxford: BSHS Monograph 9, 1994).
7 A. J. Meadows (ed.), *Development of Science Publishing in Europe* (Amsterdam: Elsevier, 1980).

extent in 1815, had been a congress of states of various sizes; competing, generally in peaceful coexistence, in opera houses and universities, until bullied into union by Bismarck. The nineteenth century was not a peaceful time in Europe: 1830 and 1848 had been years of revolutions; the Greeks had won independence in a war beginning in 1821; Spain had had civil wars; Russia had fought Britain and France in the Crimea (and also in the Baltic); Poland had been partitioned and had no separate existence; Lithuania had been swallowed up by Russia; Norway lacked independence; and Ireland was a part of the United Kingdom, though 'Fenian outrages' of terrorism and heated debates about 'home rule' indicated instability. Chemists and other scientists were often patriotic or nationalistic; but, except perhaps for some Frenchmen and Germans after 1870, they did not hate and despise their opposite numbers in hostile countries. The republic of letters persisted in the realm of chemistry; perhaps because the direct role of science in warfare was not so apparent as it became in the 'chemists' war' of 1914–18, especially with the use of poison gas – which led to the ostracism of German chemists for a decade afterwards.

In this book, then, we are examining an important feature of the intellectual and economic history of Europe. In this story, there are: the central powers (France, Germany and Britain), where the major institutions and developments were located; some medium-sized countries from the chemical point of view (Italy, Russia, Spain, Belgium, Ireland and Sweden), where some eminent chemists worked and important events happened; and some peripheral ones (Greece, Portugal, Denmark and Norway, Lithuania and Poland) which were at this time essentially importers of chemistry, with different connections over time to major or medium countries. Travel, translation and political alliances all played a part in the transmission of chemistry across these various frontiers.

Much has been written about the three major powers, and some of the medium ones; but there is very little, especially in English, about the peripheral countries. Because of this, we have chosen to give about two units of space (Britain has three, but they are shorter!) to the big three; and one unit to all the others on our list, without regard to the intellectual or industrial importance which might be assigned to them in any attempt at ranking. The book is one of the results of a programme on the Evolution of Chemistry sponsored by the European Science Foundation; and we have tried in our workshop sessions, in which precirculated drafts of these chapters were discussed, to bring out connections and parallels as well as differences, and not merely to tell a number of distinct and particular histories. Not every country could be represented; but we have had a wide selection of nationalities and very stimulating sessions, each in different countries, and we hope that the sidelining of, among others, Finland, Hungary, the

Netherlands and Switzerland will stimulate other people to write about them, and not invalidate our attempt at a European perspective.

Each country has its particular history, and chemistry has developed there differently; and our different languages cut up the world differently. We are dealing with the appearance on the scene, and the careers, of those who came to be called 'chemists', and who by the end of the nineteenth century saw themselves as 'professional'. We find that there is no simple definition possible for either of these terms. Specialisation came at different rates in different countries: educational systems were different; frontiers between chemistry and physics, or between chemistry and medical sciences, were differently drawn; and the numbers and prestige of chemistry graduates working in industries were variable. We have to ask what the word 'chemist' meant at a given time and place, and cannot expect to read back into the past just what we read into the name now. Nevertheless, we do see the rapid growth in the number of people having recognised qualifications working in industry, in government and in the educational world, who would regard themselves as chemists. They would join a chemical society, and attend some of its meetings; and read, or even subscribe to, a chemical journal: though their first description of themselves might be 'civil servant,' 'engineer,' 'scientist,' 'manager,' 'lecturer' or 'teacher,' they would also call themselves chemists.

Profession is also a slippery word. In Britain, it evoked the three old learned professions, those of the clergy, lawyers and physicians, whose education gave them a status within society. However, it could also in the nineteenth century be used to describe the business, rather than the liberal part, of the science: thus Michael Faraday was described in John Tyndall's obituary[8] as having given up professional duties (analyses done for a fee) in order to concentrate upon electrochemistry and electromagnetism. And in this sense a footballer becomes a 'professional' when he gets a salary for his activity. Being paid for chemistry is certainly part of what we mean when we talk about professionalism; but standards of behaviour are also indicated. We can say that during the nineteenth century a number of career paths opened up before the trained chemist; but also that 'profession' did not mean quite the same thing in Germany[9] and in Britain,[10] for example.

The safety-lamp, synthetic dyes and high-explosives fitted a model of pure

[8] J. Tyndall, Faraday as a Discoverer, *Proceedings of the Royal Institution*, **5**, (1866–9), 199–272, on p.266.
[9] C. E. McClelland, *The German Experience of Professionalization: Modern Learned Professions and their Organizations from the Early 19th Century to the Hitler Era* (Cambridge: Cambridge University Press, 1991).
[10] C. A. Russell, N. G. Coley and G. K. Roberts, *Chemists by Profession* (Milton Keynes: Open University Press, 1977).

science leading to applied science; and by the end of the century this had become the generally-accepted version of technical progress. It did not fit much that happened in the late eighteenth and earlier nineteenth centuries, where Davy's highly-regarded researches on tanning and on agriculture, for example, simply vindicated the best existing practice in those industries, providing a scientific rationale for what had been empirically achieved. Such mere practice came to be seen as opposed to real science;[11] and so the craftsman was replaced by the professional, well grounded in chemistry, while élite educational institutions concentrated upon pure rather than applied science. This division would not have seemed meaningful to Davy's generation; it has aspects of snobbery, but is perhaps also another indication of the specialisation which was such a feature of the nineteenth century.

Readers will find in the chapters which follow a series of connected stories, with familiar themes and unfamiliar features; and will we hope encounter the pleasure of recognition and the sting of surprise as they encounter similar but different chemical cultures. They will learn a little chemistry, and a great deal about chemistry; and indeed about science in general, and the way in which it transformed society in the nineteenth century, which can indeed be called the Age of Science.[12]

Durham
January, 1998

David Knight

[11] R. Bud and G. K. Roberts, *Science versus Practice: Chemistry in Victorian Britain* (Manchester: Manchester University Press, 1984).
[12] D. M. Knight, *The Age of Science*, 2nd ed. (Oxford: Blackwell, 1988).


EUROPE, c.1815
Scale 1:15,000,000 (240 miles = 1 inch)
Boundary of German Confederation, 1815
United Kingdom and Hanover, united under the same ruler 1815-37
Austro-Hungarian military boundary zones, with date of duration
OL. Oldenburg
ATLANTIC OCEAN
NORTH SEA
UNITED KINGDOM
IRELAND
SCOTLAND
WALES
ENGLAND
Dublin
Edinburgh
Glasgow
Liverpool
Manchester
Hull
Birmingham
Norwich
Bristol
London
Shetland Is.
Orkney Is.
Faroe Is. to Den.
English Channel
Channel Is.
NORWAY
Bergen
Christiania
Stavanger
Union 1815
Göteborg
DENMARK
Copenhagen
Aalborg
Malmö
Bornholm
Heligoland to Br.
Amsterdam
Antwerp
Cologne
Calais
Lübeck Free City
Hamburg Free City
Bremen Free City
HANOVER
Minden
WESTPHALIA
Berlin
BRANDENBURG
Stettin
LUSATIA
K. OF SAXONY
Leipzig
Erfurt
Frankfurt Free City
Prague
BOHEMIA
Nuremberg
BAVARIA
Munich
Salzburg
Innsbruck
Stuttgart
WÜRTTEMBERG
Strasbourg
Basle
Berne
SWITZERLAND
Geneva
LUX.
LOW. RHINE
FRANCE
Paris
Orléans
Nantes
Tours
Limoges
Lyons
Bordeaux
Toulouse
Marseilles
Grenoble
Nice
SAVOY
Turin
PIEDMONT
Genoa
Milan
LOMBARDY-VENETIA 1815 to Austria
Trent
Venice
Trieste
Bologna
SAN MARINO
Florence
TUSCANY
PAPAL STATES
Rome
Pontecorvo
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Naples
Palermo
K. OF THE
Elba
Corsica
Ajaccio
SARDINIA
Sardinia
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MONACO 1815-61 Sardinian Prot.
SPAIN
PORTUGAL
Lisbon
Oporto
Braganza
La Coruña
Valladolid
Burgos
Pamplona
Saragossa
Madrid
Toledo
Valencia
Barcelona
ANDORRA
Seville
Granada
Cartagena
Gibraltar to Br.
Ceuta to Spain
Tangier
Melilla to Spain
Oran
Algiers
ALGIERS
Bona
Tunis
TUNIS
MOROCCO
Malta to Br.
Balearic Is.
MEDITERRANEAN
West from Greenwich
East from Greenwich


Nikolaystad (Vasa)
L. Onega
L. Ladoga
Olonets
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Kronstadt
St. Petersburg
G. of Finland
Narva
Revel
Uppsala
Åland Is.
Stockholm
Novgorod
Volga
Jaroslavl
Nizhniy Novgorod
Kazan
Pskov
Tver
Moscow
Gotland
Riga
Calmar
Öland
Oka
Tula
Tambov
Saratov
Polotsk
Tauroggen
Smolensk
Vilna
Königsberg
Danzig
EAST PRUSSIA
Grodno
Minsk
Desna
Gomel
Bialystok
Pripet
Belograd
Thorn
POLAND
Warsaw
Bug
From 1815 united with Russia
1831 fully part of Russia
Posen
Kalisch
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Donets
Poltava
Breslau
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Oder
Vistula
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Pressburg
Erlau
Dniester
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MOLDAVIA
Trib.
Kherson
Odessa
Sea of Azov
Kerch
GREAT KABARDIA
From 1825 complete Russian Control
Circassians
Buda (Ofen)
Pest
Grosswardein
HUNGARY
Galati
Crimea
Sevastopol
Mohacs
Temesvar
WALLACHIA
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Poti
Batumi
Belgrade
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Trib.
BLACK SEA
Danube
Varna
Sinope
BOSNIA
Sarajevo
HERZEGOVINA
DALMATIA
Nish
BULGARIA
Sofia
Philippopolis
Trebizond
Amasia
MONTENEGRO
Ragusa
Cattaro
Adrianople
OTTOMAN
Üsküb
THRACE
Constantinople
Scutari
Nicomedia
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Aleppo
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Athens
Messina
Reggio
Patras
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Thorn
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POSEN
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Don
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HERZEGOVINA
SERBIA
1878
BULGARIA
Varna
Danube
1908
Trebizond
Sofia
EAST RUMELIA 1885 to Bulg.
1913 to Bulg.
Amasia
Ragusa
Cattaro
1913 to Serb.
Üskub
1913 to Bulg.
Adrianople
Constantinople
Scutari
Izmit (Nicomedia)
Marmara
Sivas
Durazzo
ALBANIA
1913
MACEDONIA 1913 to Greece
Salonica
Bursa
Angora
OTTOMAN EMPIRE
Kayseri
Taranto
Euphrates
THESSALY 1881 to Greece
Corfu
1913 to Greece
Konya
Smyrna
Adana
GREECE
1830
Athens
Messina
Reggio
Ionian Is. 1863 to Greece
Patras
Corinth
Piraeus
Adalia
Aleppo
PELOPONNESE
Navarino
Dodecanese 1912 Italian Occup.
Rhodes
Cyprus 1878 Br. Prot. Annexed by Br. 1914
Nicosia
Cerigo
Crete 1908 to Greece
Damascus
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